Topic 1

Temperature Variations and Habitability

Considering a Real World Problem

Searching for Life in Extreme Environments

The Problem

A wide range of environmental conditions characterizes regions around the globe. What factors or conditions do you think are essential to sustain human life and how do they interact to produce a habitable temperature? What locations on Earth do you think represent the most extreme environmental conditions in which human life can survive? Based on what you have learned and discussed with your classmates, indicate the magnitude of the differences in these environmental conditions.

Consider the extremely high temperatures inhabited by microorganisms in Yellowstone National Park. Are there other extreme environments on Earth where scientists can search for life forms other than human? Based on the ideas discussed in this topic, what are the implications for the existence of life on other planets?

From this initial study of some of the extreme temperatures that exist on Earth and other planets in our solar system, offer your perspective on the types of negative and positive consequences that may occur if adjustments or changes are made to the essential factors or conditions that make Earth a habitable planet.

Figure 1.1. Wyoming's Yellowstone National Park is one of the most famous geologic landmarks in the United States. In addition to the dramatic canyon landscape, water boils in geysers and hot springs up to 92°C (198°F). While such temperature extremes are not hospitable to humans, microorganisms such as bacteria live and grow in these environments.

Activity A

Observing, Describing, and Adapting to Temperature Variations

Overview

We experience temperature variations where we live. We also know that people around the globe live in environments with conditions different from ours. Environmental conditions that exist on planets within our solar system differ greatly from Earth, even on our closest neighbors, Mars and Venus.

Collectively, the class will decide upon a plan for describing the day, including general observations and specific measurements. Two teams will be set up to describe the indoor and outdoor environments. Several instruments will be available to collect data. Data is to be recorded and compared. The References provide data on environmental conditions at other Earth locales and planets in our solar system. These will be used to discuss temperature ranges that exist, their relation to habitability, and ways to adapt to these conditions.

Learning Objectives

- ✓ Identify a minimum of five factors useful in describing local environmental conditions.
- ✓ State the range of temperature variability on the earth.
- ✓ State the range of temperature variability within our solar system.
- ✓ Explain the connections among quality of life on Earth, temperature variability, and the environment.

Relevance

How do humans modify their environment to make it more livable or habitable? This is an important question as it concerns the resources needed to adapt to environmental conditions. It also relates to the consequences on human health and economic productivity if we cannot make necessary adjustments. Finally, this question is connected to human exploration of other inhospitable planets and our ability to adapt to these environments using scientific inventions.

Observing, Describing, and Adapting to Temperature Variations

Materials

Access to the outdoors, instruments to measure weather phenomena (thermometers, barometers, anemometers, etc.), images of Earth and other planets that represent temperature extremes.

Methods

Preliminary Discussion and Planning

1. Determine a plan for describing the indoor and outdoor environment by identifying the observations to make, as well as measurements needed to quantify your descriptive statements.
2. Divide into two investigation teams, one to study the indoor environment and the other outdoors.

Observations

1. Take 15 minutes to make your observations and collect measurements.
2. Record your data on the Data Sheet: Observing and Describing the Day.

Data Analysis, Comparisons, and Consensus

1. Exchange observations in class. Are there differences or similarities? What is the magnitude of the differences, if any?
2. Discuss: How do humans modify their environment to make it more livable?
3. Study the Reference viewgraphs of sites in the Sahara and the Antarctic.
4. Discuss: What if this activity were moved to these locales? How do we adapt to these environments?
5. Study the References of the atmospheric and surface features of Earth and other planets.
6. Discuss: What are the temperature ranges? Magnitude of differences? Why is Earth special to humans?

Investigation Notebook

1. Your plan for taking measurements that describe the day.
2. Data Sheet: Observing and Describing the Day.
3. Questions: Observing and Describing the Day.

Observing and Describing the Day

Task

In a few moments, part of the class will go outside with the goal of describing the conditions they encounter outdoors. They will want to make as complete a description as possible. The other part of the class will remain in the classroom and describe the conditions there as completely as possible.

Break up into groups of five students each. Each group of students must decide in 10 minutes how they will go about describing the conditions of their assigned location. After they have decided what they would like to describe, they will determine what tools they may need and ask the teacher for those tools.

All the groups will then go to their respective locations and make their observations. Record these observations in the table below. In each box write the type of measurement being taken and record the observation. For example, if you are outside and observe cloudy sky conditions with your sight, your box can read: Eyeball Sky Conditions/Cloudy. When the groups reassemble in the classroom, each group will present its description to the class.

Location

Circle the location your group is observing: **Indoor** **Outdoor**

Observations

Student 1	Student 2	Student 3	Student 4	Student 5

Observations of Local Conditions

Observing and Describing the Day

1. What are the differences and similarities between environmental conditions indoors in the classroom and outdoors? What is the magnitude of the differences?

2. How do humans modify the environment to make it more livable?

3. If this activity were moved to the Sahara or the Antarctic, how could we adapt to those environments?

4. What makes Earth special to humans?

5. Consider the temperature differences that exist between Earth and Mars, and Earth and Venus. Do regions exist on Earth that can experience similar high or low temperature differences? Use the map in figure 1.2 below to answer this question. If yes, identify these regions and the temperature ranges. Calculate the magnitude (stated in percent) of these temperature differences. For example: Region X's highest recorded temperature was 30% or 40 degrees higher than Region Y's lowest recorded temperature. Relate these differences to the temperature differences found between the planets.

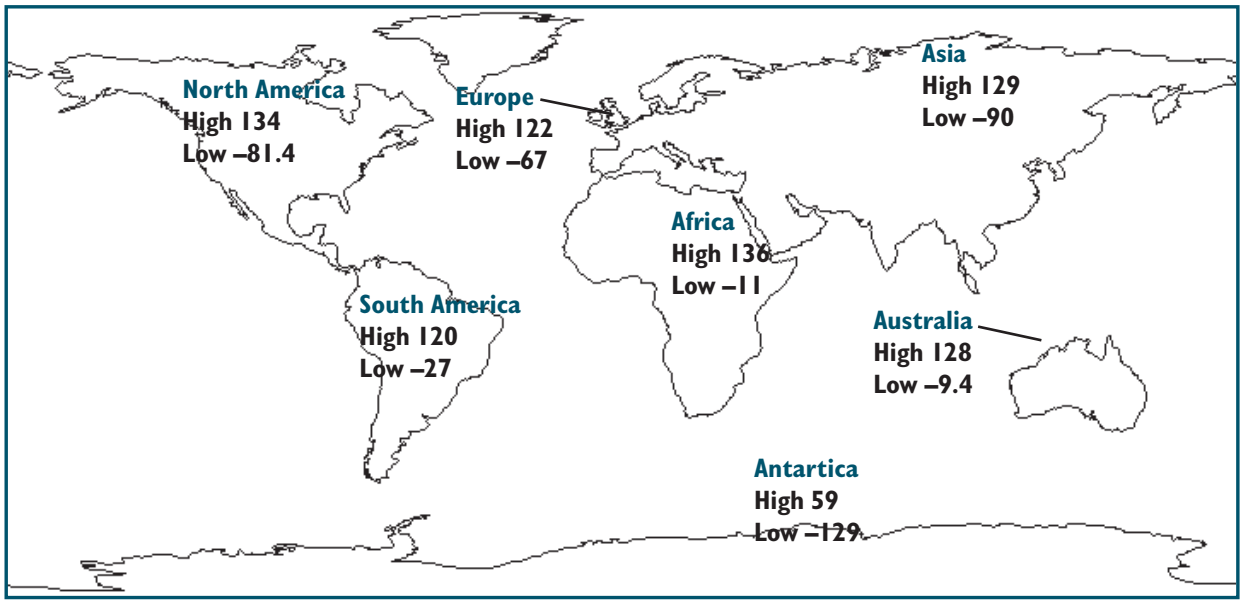

Figure 1.2. Global Measured Temperature Extremes (in °Fahrenheit).

The Sahara and the Antarctic

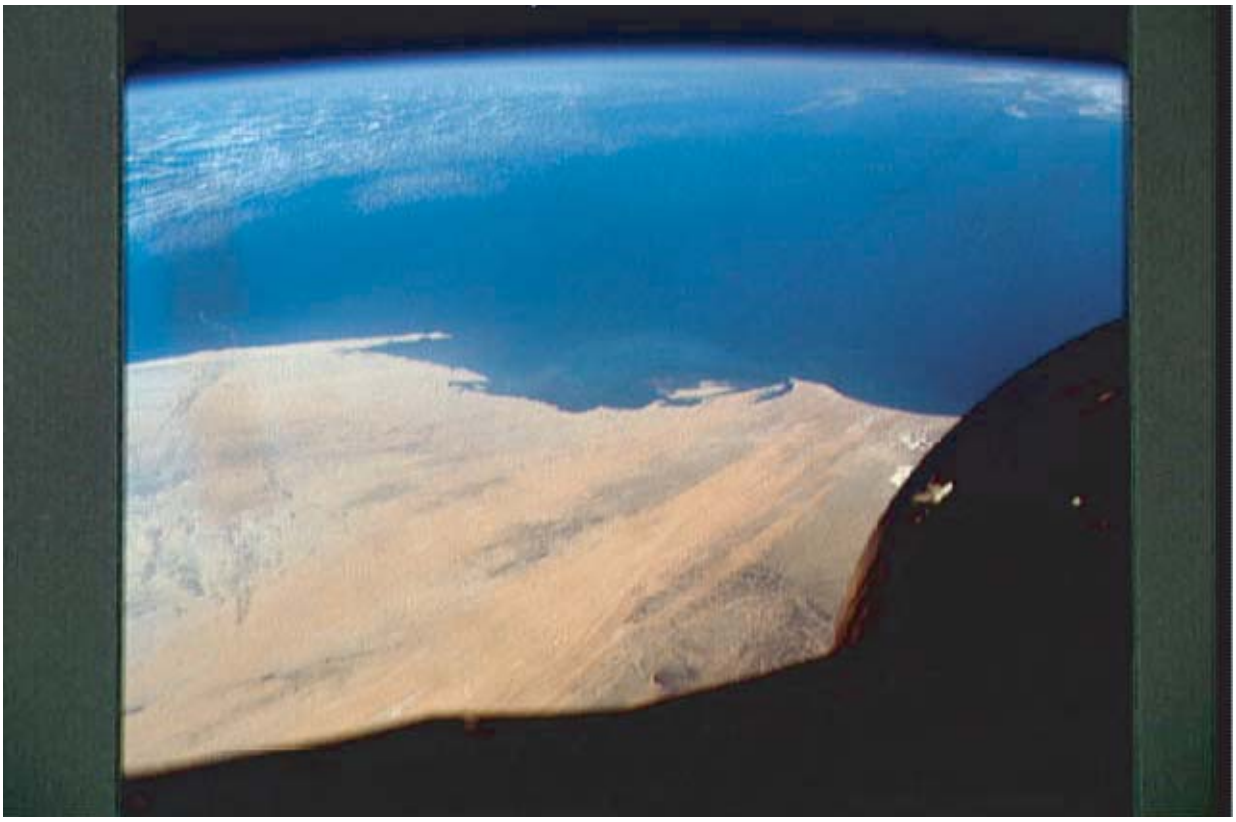

Figure 1.3. A view of the Sahara from space.

Figure 1.4. Antarctic ice.

Earth, Mars, Venus and Pluto

Figure 1.5. Earth.

Figure 1.6. Mars.

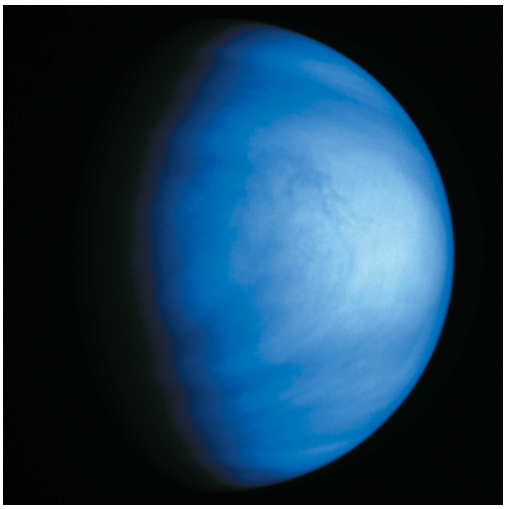

Figure 1.7. Venus.

Figure 1.8. Pluto and its moon Charon.

Comfort Adjustments in Our Solar System

Comfortable Temperature = 70°F

Place	Average Temperature (°F)	Comfort Adjustment (°F)
Sahara Desert	89.9	–19.9
Sahara Desert (extreme)	135.9	–65.9
Antarctica	–94	164
Antarctica (extreme)	–128.6	198.6
Earth	59	11
Venus	856	–786
Mars	–76	146
Pluto	–370	440

Table 1.1. Adjustments to temperature extremes to achieve a "comfortable" temperature.

Activity B

Relating Factors that Influence Planetary Temperature and Habitability

Overview

Planetary systems have basic inputs and variables that produce average temperature and influence habitability. Some of these inputs and variables have been discussed in the previous activity where you identified certain modifications humans need to do in order to make their immediate environment more comfortable and livable. How these inputs and variables interact is an important step in understanding their influence on planetary temperature and habitability.

Your teacher will divide the class into small teams to construct a "knowledge map" of the essential characteristics or factors of a planet with a habitable climate. Each Knowledge Map represents a group's consensus about the 10 essential factors needed for a habitable planet and the relationships among them.

Learning Objectives

- ✓ Give three examples of how humans modify the environment to improve livability.
- ✓ Identify three factors that may determine the average temperature of a planet.
- ✓ Identify a minimum of five factors that may determine the habitability of a planet.
- ✓ State the importance of maintaining habitable temperature on a planet.
- ✓ Briefly describe the links between two sets of factors of your choosing.

Relevance

Even under some of the most extreme conditions here on Earth – the Antarctic and the Sahara – humans have been able to make the necessary modifications to live (at least briefly) in these places. As humanity begins to explore other planets in our solar system, the idea of what makes a place habitable takes on a wider meaning, especially when humans begin to set foot in these remote areas.

What determines the habitability of a place? What are the major factors that determine the habitability of a place located anywhere in our solar system? How are these factors related to one another?

Investigation Activity B

Relating Factors that Influence Planetary Temperature and Habitability

Materials

Post-it™ (or similar) notes, colored linking strips made by cutting index cards lengthwise, large sheets of poster paper, and markers.

Methods

Preliminary Discussion and Planning

1. Each group should select one person as a recorder to diagram the Knowledge Map.
2. Discuss and make a list of approximately 10 essential characteristics or factors and then write each characteristic on a separate Post-it™ note at your table.
3. Discuss some of the possible relationships among the factors.

Preparing the Knowledge Map

1. Group the Post-it™ notes that are most closely related together on a large poster sheet.
2. Indicate strong relationships using the linking strips. Place these links between the related Post-it™ notes and write a brief explanation of the relationship next to each link. Be prepared to explain why you chose your characteristics, how they are related, and how they contribute to forming a planet with a habitable climate.

Defending the Knowledge Map

1. After each group has completed its Knowledge Map, the groups will be divided into Presenters and Questioners.
2. Questioners will be assigned the task of examining the Knowledge Maps of a group. The Presenters will explain their choices and the relationships they have indicated within the Knowledge Map. The Questioners are then free to ask questions about the map or the relationships. A different member of the presenting group should answer each question.
3. All Questioners complete a Knowledge Map Assessment Data Sheet as the evaluation for the group they questioned.

Investigation Notebook

1. Data Sheet: Knowledge Map.
2. Date Sheet: Knowledge Map Assessment.
3. Questions: Relating Factors that Influence Planetary Temperature and Habitability.
4. Essay: Topic 1: Searching for Life in Extreme Environments.

Knowledge Map

Draw a diagram of the Knowledge Map your group created. Label the planetary system inputs, variables, and outputs.

Number the links in your diagram and explain the relationships below.

Data Sheet — Activity B

Knowledge Map Assessment

Presenting Team _____

Questioning Team _____

Evaluation Criteria	Requirements for the Criteria	Comments	Completed (place ✓ if criteria met)
A minimum of 10 habitability factors selected.	All 10 factors must relate to habitability for humans.		
The reason for selection of each factor must be explained adequately.	The group must give a short, valid explanation as to why they selected each factor.		
A minimum of three relationships between factors must be shown.	There should be three connecting to a maximum of two factors.		
The nature of each of the links should be explained clearly.	The group should be able to clearly and accurately explain their indicated links.		
The overall Knowledge Map should be clear and logical.	The 10 factors and links should be arranged clearly and logically. The Knowledge Map should be easy to read.		

Additional Comments:

Relating Factors that Influence Planetary Temperature and Habitability

1 .What are some of the factors that determine the habitability of a place?

2. What are some of the essential factors that determine the habitability of a place located anywhere in our solar system?

3. How are these factors related to one another to produce a habitable climate?

Essay Topic 1

Searching for Life in Extreme Environments

Write a 300 word essay that responds to the questions in this topic's Real World Problem (refer to page 6). You should use at least one reference in your essay. Consider the following: encyclopedia, science magazines, textbooks, the Internet. Be sure to cite the reference(s) you decide to use.